UCDAVIS
ENVIRONMENTAL STEWARDSHIP AND SUSTAINABILITY

Labs21 Equipment Survey Protocol

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Prepared: 2006-2010 (DRAFT May, 2010)

Contents

Introduction

There are three priorities for lab power measurements done in the field by laboratory students and researchers or facilities staff

1) Understand design needs for architects and engineers in Watts per square foot. This impacts electrical demand and the number of outlets needed, and it impacts reject heat needing cooling by the HVAC system. This can be accomplished by panel measurements or a comprehensive inventory for one lab and their use patterns. This will be assisted by comparing measured power with name plate power listings.

2) Compare functionally equivalent pieces of equipment to empower researchers to select lower energy using equipment, similar to Energy Star ratings though done on a less controlled basis than manufacturer testing. By collecting user data and user performance satisfaction reports, this can leverage users and manufacturers to work together for better performing equipment.

3) Identify use patterns for efficiency. How much energy does it save to change temperature settings or to go to standby mode, and how to motivate researchers to use appropriately.

These instructions will guide you to making 1) power estimates for a complete laboratory or 2) power measurements for priority equipment, and then reporting it to the Labs21 WiKi website. The visual survey gathers information from name plates on the equipment then getting manufacturer data if available.

Please make data submissions a priority project for your students or staff!

http://labs21.lbl.gov/wiki/equipment/index.php/Energy_Efficient_Laboratory_Equipment_Wiki

Laboratory Equipment Power Measurements

Introduction: Taking measurements in the field

Any manipulation (a.k.a. touching) of research equipment MUST have lab manager or PI permission first, and it is ESS policy that all measurements will be logged in writing to document appliance proper functioning and facilities alarm notification. Students may measure most equipment that can be unplugged from the wall without professional supervision.

In some laboratories we have priority equipment or the manufacturer cannot provide power data, so we take our own measurements. There are several power meters available depending on whether the equipment uses 110 V and 15 or 20 Amps, or whether it uses 208 V. For higher amperages or voltages you will need some specialized meters, and you may need an electrician or electronics engineer to make adapter plugs for inductive measurements.

These measurements need to be under controlled conditions that you will describe on the WiKi site, yet they will likely not be as consistent as Energy Star or standardized tests. Given the lack of power data (2008) your measurements will provide valuable information for prospective buyers or laboratory designers.

Power measurements are an investment of time, care and materials to get higher voltages and amperages. Your campus electricians likely have some of this and they may let you borrow it until you get experienced and convinced you want to pursue this.

Preparation

1) Identify Labs with equipment for surveying.
2) Contact Lab Managers. Verify that lab managers notify all lab users about the survey.

Dear (Lab Manager),

Where do we purchase energy efficient laboratory equipment? There is very little manufacturers' data available. Our group (name) would like to take power measurements from selected equipment in your lab if convenient. We would briefly unplug the equipment, then plug it into our power meters for several hours or even overnight, and then switch the meter to the next piece of equipment. With your permission we also may request to try different settings (temperature, speed, humidification, standby status, etc.).

The results of these tests will be entered on a national website available to all researchers so they may make informed decisions when buying equipment. Your comments about performance and maintenance are also welcome.
http://labs21.lbl.gov/wiki/equipment/index.php/Energy_Efficient_Laboratory_Equipment_Wiki

We are requesting permission for two people to enter your lab for power measurements when lab personnel are present. If you have concerns about these measurements, please contact me or our coordinator, (colleague's name). After each piece of equipment is returned to its full power state, we will confirm its status with someone in your lab.

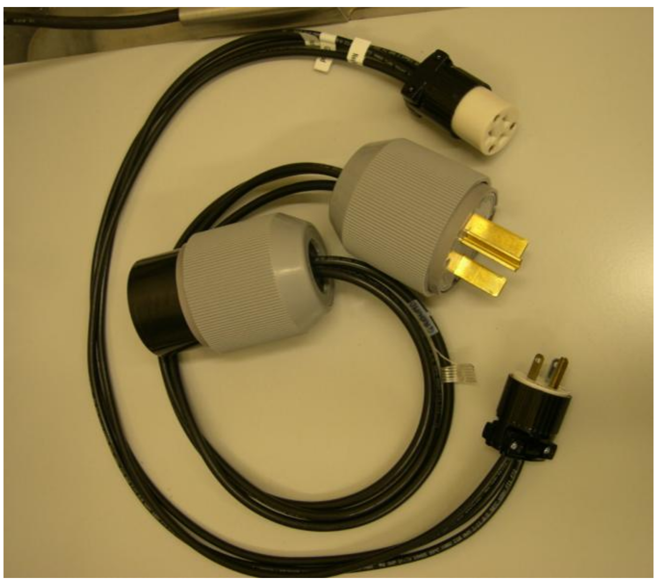
If you are not responsible for these rooms, could you forward this to an appropriate person? Please contact me if you have any questions.

Thank you,
(Your Name)

1. Power Measurements

Plug connections:

For 110 V appliances 15 Amps and under, you may plug the appliance directly into a WattsUp meter (Section 3.2). For higher Amperages and Voltages, you will need "pigtails" with split conductors so you can clip "CT's" around one, two or three conductors to inductively measure current flow. The connectors must match the NEMA code for the male plug and female receptacle, respectively, and should be wired by a licensed electrician. You will likely need: 5-20, 6-20, 6-15, 6-30, and L6-20, approximately in order of occurrence. See NEMA table in appendix for other types. Typical cost is surprisingly high, can cost about $50-75, depending on the type of plug and receptacle.



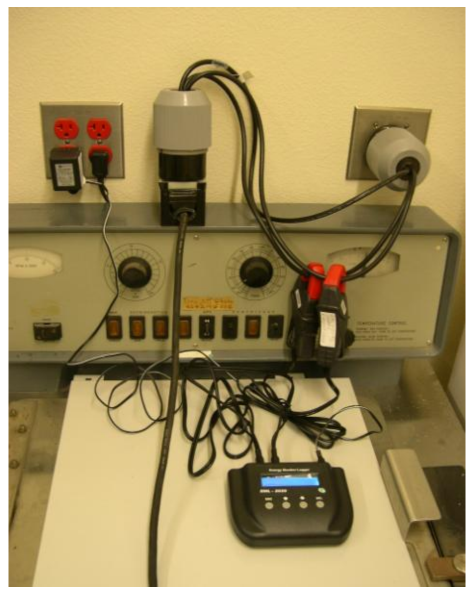


Figure xx a. Two pigtails. b. WattsUp Pro using current CT's on a NEMA 6-30 pigtail measuring two legs of 3-phase power.

Due to the high cost for some plugs, the decision process of payback for a new plug is very important. This includes the discretionary power use, number of the same equipment,

Discretionary power use depends on whether the equipment may be turned off while meeting experimental needs, and power consumption. Can regular turn-offs be predicted manually and with timers? Will power consumption data motivate users to power down? Estimation for power consumption can be done by using the measured Amps-to-name-plate-Amps ratio of similar equipment, and multiplying by the name plate amps of the unmeasured equipment. While this value may be uncertain, it can assist with the decision to get a pigtail. If there are multiple items, this increases the value of power savings and shortens payback.

An example for a more costly connector is the 4-prong plugs. They are usually found in larger ultra low temperature freezers and drying ovens. Because 4-prong plugs are so rare, you might want to ensure the payback time for purchasing the timer is reasonable. Payback time can be determined from the savings from installing timers, better manual control and management, signs, and encouraging more efficient purchases in the future.

3.1. Kill-A-Watt Meter

This is the most inexpensive meter and also a bit fragile. With repeated use its plugs can work loose from the internal circuit board and short out, in other words: disaster. Because it plugs directly into the outlet, it also may not be visible if plugged in behind a refrigerator, for instance. Both these disadvantages can be solved if it is dedicated to a short extension cord with grounding so that its prongs are not repeatedly unplugged and it may be laid on a counter for easy reading.

As soon as you plug an appliance into it, it begins to log time and total Watts. You can get average kWh/day from this meter, but not detailed time data.

Figure : Kill-a-Watt meter, camera and light loggers. Because the male prong connections are a little weak and appliances may block reading the meter, it is best to clamp or cable tie this meter to a power strip or extension cord. It can't handle more than 15 Amps or 120 Volts.

3.2.
3.3. Watts Up Pro (USB models)

Program Meter :

1. Connect meter to USB port
2. Open Watts Up Pro USB software (free download from wattsupmeters.com)
3. Click *Meter Settings* menu item and then click on the *Logged Items* tab
4. Check the following *Items to Log* (Figure 1)
    a. Watts (this is an average over the time interval you manually choose or is automatically chosen for you)
    b. Watt Hours (you can determine this manually, but is easier to have the meter do it for you)
    c. Max Watts (this is helpful for determining thermal load on the space)
    d. Volt-Amps (this is helpful for right-sizing the electrical distribution system)

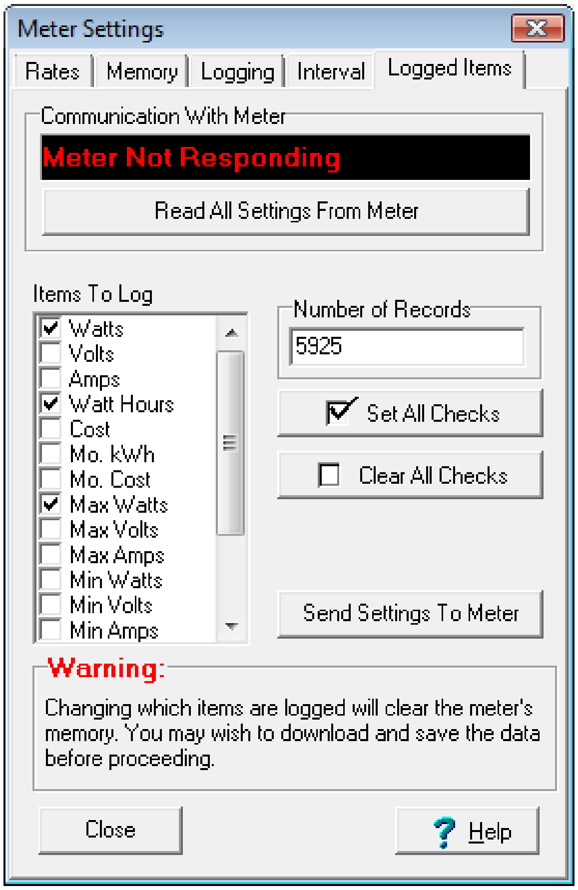


Figure 1: Logged Items

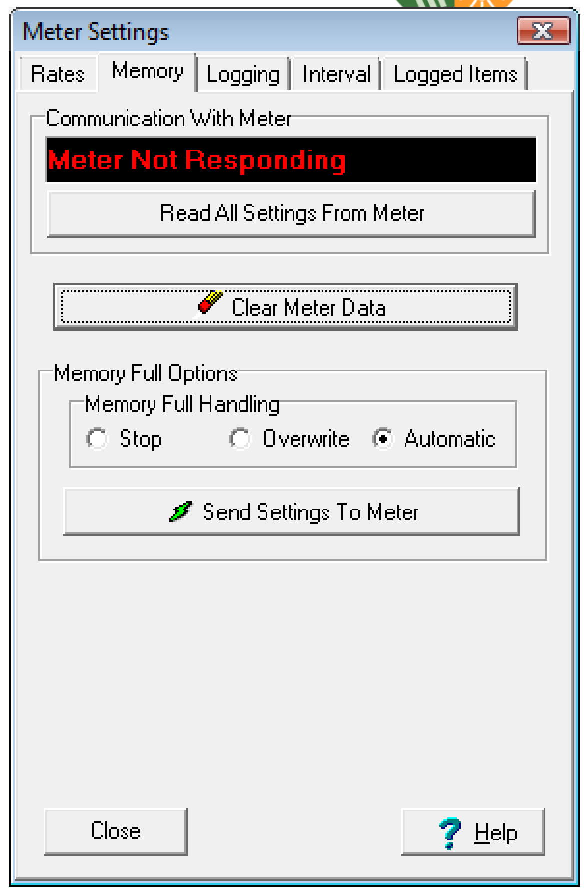


Figure 2: Memory Settings

5. Set the meter to automatically adjust metering interval to account for full memory (Figure 2)
   a. If you need a fixed metering interval (i.e. 15 minutes) then you can set the *Memory Full Options* to "stop" or "overwrite" and then change the *Logging Interval* on the *Interval* tab accordingly
   b. In "automatic" mode, the logger will adjust the logging interval to make more space when it runs out

6. Click the *Send Settings to Meter* button

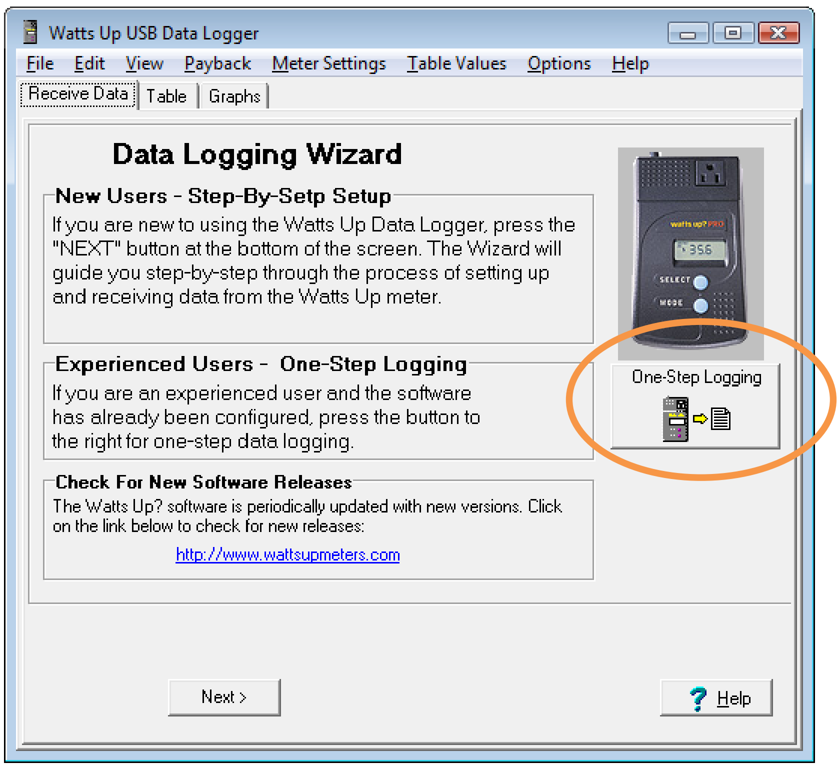
Install Meter

1. Check with the Lab Manager and equipment users before unplugging any device
2. Be sure you are familiar with safety precautions.
3. Unplug the piece of equipment you wish to monitor and plug in meter in its place
4. Plug the piece of equipment into meter

5. Pay special attention to making sure the meter is not obtrusive or otherwise in a user's workspace
    a. Use twist ties for cord management
6. Revisit the equipment that day to make sure the meter is not interfering with its operation, especially if it is a storage appliance with samples in it.

Download Data from Meter

1. Connect meter to USB port
2. Open Watts Up Pro USB software
3. Click *One-Step Logging* (Figure 3)
4. From the *File* menu, click *Save Table As* and choose an appropriate name (Equipment model #)



1.3.1* Figure *3:* Watts Up Pro *USB Software

3.4. Elite Pro Meter

This sophisticated meter measures many different voltages and currents, and is a work horse with the electrical shop at UC Davis. The office of Environmental Stewardship and Sustainability gets them on loan from PG&E through their tool lending library, (link below).

These meters measure inductively, so you will need access to single phase conducting wires (with insulation). As this is not possible on a multi-strand wire, you will need adapter pigtails made by qualified electricians such as in upper left of Figure 4.

The instructions can be viewed from the PGE website.

1.3.2 **Figure 4:** Three Elite Pro meters, eight 20 and 50 Amp CT’s, 110 and 208 V pigtails, the software CD and serial connection cable. (Serial to USB adapter not shown). For frequent use the CT’s need securing to the green strip to avoid shearing the leads and frequent re-stripping. If only Amps and Volts are recorded, power factor will not be included in measurements, which may range from 0.5 for computers to 0.85 for motors, to close to 1.0 for ovens.

2. Prepare Data for Labs21 Wiki

1. **Open the TXT file using Excel and select the delimiter as "tab"**
2. Save the file as an XLS file for further analysis. Graph power versus time. Consult the WiKi site for graph formatting consistency. (Can they download a generic Excel graph to import their data?)
3. Consult Labs21 Wiki editor or moderator for help with analysis and upload relevant data to Wiki. What does this mean? Will they attach figures to the WiKi site? That would be cool!

http://labs21.lbl.gov/wiki/equipment/index.php/Energy_Efficient_Laboratory_Equipment_Wiki

Safety Considerations

Panel Connections These must be made by someone with University authority to open panels and work with live power.

Description of how to set up meter with someone like Fred Torres

Sample Security Considerations
In order to get a power measurement on lab equipment, they must be briefly unplugged to install a patch cord. The ULT technician says it is OK to unplug ULT freezers to install the patch cord. This has been cleared with campus superintendent.

Always, Always check with a lab manager BEFORE unplugging a freezer. A "lab manager" is preferably a full time employee or long time grad student. **Always, Always** check that the freezer has power AFTER you reconnect it.

When we unplug an alarmed freezer, the facilities maintenance shop is alerted. They need to respond and log their response if they don't know we are intentionally cutting power, even briefly. We need to call their number any time of day to let them know what alarm #, room number etc. we are working in. Each keypad has an account (room) and zone that you may give the dispatcher.

Be sure to log every time you unplug and re-plug a freezer and check that it's operational. These measurements cannot afford any equipment malfunctions due to our measurements.

Log book example: Lab staff initials required after power restored; supervisor initials daily.

Date	Logger #	Bldg/ Rm#	Item	Model #	Action/ Time	Lab Initials	Supv Initials	Comments

Other considerations that you need to learn about:

Single phase power

Three phase power

Power factor – The ratio of the amount of consumed power (measured in *Watt*) to the amount of absorbed power (measured in *Volt-Amp*). This ratio is also the same as the cosine of the angle of the circuit's impedance in polar form.

Examples of Emails to Request and Describe a Power Measurement

Dear Lab Manager,

I am the Energy Assistant for the Office of Environmental Stewardship and Sustainability in Mrak Hall. We assist researchers to conserve energy in their workplace, and promote smart sample management in laboratories to use energy and resources wisely. This includes purchase and efficient use of equipment, as well as dry storage for DNA and RNA, and even whole tissues. This is partly accomplished with the Energy Efficient Laboratory Equipment Wiki, which provides purchasing information to minimize energy use in laboratories while simulating manufacturers to supply efficient equipments. This task cannot be accomplished without field measurement; therefore, I am emailing you to seek for your cooperation.

In order to get a power measurement on lab equipment, they must be briefly unplugged to install a patch cord (~10seconds). The campus ULT technician, Ed Tandy, says it is safe to briefly unplug ULT freezers to install the patch cord. This has been cleared with Superintendent Michael Clearwater. To ensure further safety, the best practice will be to turn the freezer off before unplugging, and turned on after plugging in. This will not affect the performance of the freezer or the quality of the stored sample. The alarm desk will be notified of the brief power interruption, and the energy assistant [in this case, I] will remain on-site for a few minutes to make sure it operates when turned back on. After every power interruption we will ask for someone in the lab to initial our logbook to acknowledge that it is on and working.

Let me know if you have any questions or concerns

These power measurements will be uploaded onto a website available for researchers to make energy efficient power purchases and operate their equipment efficiently:
http://labs21.lbl.gov/wiki/equipment/index.php/Energy_Efficient_Laboratory_Equipment_Wiki
Select "categories" to see equipment ratings.

Best,
Assistant Name here
Energy Assistant

For further assistance and concerns, please contact
Allen Doyle
Sustainability Manager
752-2075

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Complete Lab Plug Load Assessment

This is a big project and only necessary in certain cases….

Strategies:

1. Complete inventory (for inexperienced assessors)
2. Highlighted big power users (with experienced equipment knowledge)

Goals:

Lab conservation opportunities

Building design and operation

Preparation

1. Identify Labs for Surveying.
2. Contact Lab Managers. Verify that lab managers notify all lab users about the survey.

Dear (Lab Manager),

In the process of designing future labs on campus, (name of organization) have repeatedly been faced with the difficult task of estimating electrical capacity needed for laboratory equipment. We would like to run a new data set by metering some of the labs in (lab building). We will be recording electrical loads for equipment in several labs.

We had identified the following rooms as representative lab and lab support spaces for sampling: (Room Numbers)

We are requesting permission for two people to enter these labs for equipment verification and receptacle counts on (Day), between (Time), for approximately 30 minutes.

Will you be able to help us in this effort? If you cannot speak for these rooms, could you forward this to the appropriate person? Please contact me if you have any questions.

Thank you,
(Your Name)

3. Send reminder email the day before visiting.

Enter and Record Information

Two people survey the lab: one records information and one reads nameplate data and takes pictures. Bring the following items: blank inventory forms (Empty Lab Survey Template.xls), list of labs to visit, pen, camera (charged battery and empty memory card), flashlight, and mirror with handle.

1. Introduce yourselves to Lab Manager and explain what you will be doing. (They will show you which equipment to be extra careful with).
2. Take picture of Room Number.

3. Take picture of overall Lab.

4. Fill out the Lab Equipment Inventory Form, "Lab Information," and "Survey Information."

Lab Information	
Lab name	
Room number	
Area in sq.ft.	
Lab use	
lab type	
nts	
Operation hours/week	

Survey Information	
Name	
Phone	
Email	
Institution	
City	
State, ZIP	
Date entered	

5. The photographer: Takes a picture of the entire piece of equipment, takes a picture of the nameplate data, and reads the needed information out loud to the recorder.

The recorder: Records information for the following (what you can find on equipment):

Equipment Information								
Equipment Type	Brand	Model #	Plugged in? (Y/N)	Quantity	Nameplate rated W or VA or Btu/hr	Nameplate rated Amps	Voltage (110, 220)	Notes/comments

5. Ask Lab Manager any questions you have about the pieces. (Make sure to ask what a piece of equipment is for if you do not know).
6. Ask Lab Manager for their performance comments: reliability, maintenance, cost, operation tips. (This will be valuable to attract viewers of the Labs21 Wiki.)
7. Ask Lab Manager what the typical usage hours (in a week) are for each piece of equipment. Record.

Typical usage hours: **Always (24/7),** **workday (30-40 hrs/wk),** **often (10-30 hrs/wk),** **seldom (<10 hrs/wk)** **Never**

3. Manufacturer's Specifications

Contact Manufacturers for their power data, if any.

1. Prepare/ Background Research:

- Research product. Become familiar with the product. Use the web and product catalogs. (Key sources to look for: specification sheets, technical information, user manuals).
- Contact/ talk to lab user/manager about product (if you feel this is necessary).
- Look at range of characteristics of lab equipment such as features and parameters (i.e. size, temperature range).
- Chart functional equivalency of models selected from the survey list. Include: manufacturers who produce this type of equipment, equipment size variation, other.

2. Call Manufacturers:

- Coordinate time with student interns to come into office and use phone or use personal phone
- Call 3 Manufacturers for each equipment type
- Follow the "Calling Manufacturer Worksheet" to guide conversation. Record.

Estimating if it can't be measured…

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SUPPORTER LABS21℠ SUPPORTER

		Contact Manufacturer Worksheet	
Call Manufacturer:			**Response**
1	**Opening Line:**	Whom may I speak to regarding some technical questions for laboratory equipment energy us?	
		(If needed: Is there a technical equipment representative?)	
Introduction		**Technical Representative:**	
2	**Introduction:**	My name is _____ and I am from (organization) working to create purchasing guidelines for moveable lab equipment. This effort is part of a (group name or affiliation) and universities around the country to improve energy efficiency in laboratories. May I ask you some questions regarding (FILL IN MANUFACTURER) (FILL IN LAB EQUIPMENT)?	
Energy Use		**Questions:**	
3	**Question:**	How many different power modes are there?	
4	**Question:**	What is the power draw in different power modes:	
		- Rated capacity (nameplate) (cross-check with our data)	
		- Active mode	
		- Low power modes: (includes sleep mode and all modes other than active mode)	
		- Stand by level (lowest energy consumption when connected to power)	
5	**Question:**	What is the estimated time spent in each power mode?	
		- Rated capacity (nameplate)	
		- Active mode	
		- Low power modes: (includes sleep mode and all modes other than active mode)	
		- Stand by level	
Follow up		**Questions:**	
6	**Question:**	Do you offer a more energy efficient model for (*insert equipment type*)?	
		If NO:	
6a	**Question:**	What are the features on the (*insert equipment type*)? (I.E. Insulation, high efficiency motor?)	
		If YES:	
6b	**Question:**	What is the relative price point? (% of $ more than original?)	
6c	**Question:**	Can you compare this more energy efficient model	

		to the less energy efficient model?	
Closing		**Questions:**	
7	**Question:**	Are you looking to (further) improve energy efficiency for (insert equipment type)?	
		If YES:	
7a	**Question:**	When do you expect to have this model out on the market?	
8	**Question:**	Have you been noticing more interest from consumers about the energy efficiency of your products?	

3. Finish up:
- Complete Contact Manufacturer Worksheet
- Attach cut sheets for each manufacturer
- Create a Manufacturer Contact List and add each new contact, including the following information: Date contacted, Who Contacted, Company Name, Contact Name, Contact Title, Phone Number, Email, Contact Reason, Contact Outcome, Other.

Compile Information into Equipment Database

1. Download Images onto computer. Organize and label by room number.
2. Enter data from Lab Equipment Inventory Form into Excel. (Equipment data and image number of corresponding equipment).
3. Find Missing Data. (To find power information search for technical specification sheets online and/or calculate from the information you have. Equipment type and power (Watts) are the most important to find if there is missing information).

*watts= volts x amps x power factor
(Power factor: Resistance= 1, Motor Driven= .8, Both (Resistance and Motor Driven) =.9)

4. Provide data to a Labs21 wiki editor or moderator for submission to the equipment wiki.

NEMA Configuration for Common Plugs and Receptacles

Use this table to find out the NEMA configuration for the plug for your equipment to build compatible split conductor pigtails. A good starting kit for data collection would entail 5-20, 6-20, 6-15, 6-30, and L6-20, approximately in order of occurrence. This will not allow measurement of power factor, which needs to clip into bare wires with insulating tape around the connections. That must be done by licensed electricians and not left open to the public.

Voltage	15 Ampere		20 Ampere		30 Ampere		50 Ampere		60 Ampere	
	Receptacle	Plug	Receptacle	Plug	Receptacle	Plug	Receptacle	Plug	Receptacle	Plug
2 Pole 2 Wire										
125V	1-15R	1-15P								
250V		2-15P	2-20R	2-20P	2-30R	2-30P				
277V AC	Reserved For Future Configurations									
600V	Reserved For Future Configurations									
2 Pole 3 Wire Grounding										
125V	5-15R	5-15P	5-20R	5-20P	5-30R	5-30P	5-50R	5-50P		
250V	6-15R	6-15P	6-20R	6-20P	6-30R	6-30P	6-50R	6-50P		
277V AC	7-15R	7-15P	7-20R	7-20P	7-30R	7-30P	7-50R	7-50P		
347V AC	24-15R	24-15P	24-20R	24-20P	24-30R	24-30P	24-50R	24-50P		
480V AC	Reserved For Future Configurations									
600V	Reserved For Future Configurations									
3 Pole 3 Wire										
125/250V			10-20R	10-20P	10-30R	10-30P	10-50R	10-50P		
3Ø 250V	11-15R	11-15P	11-20R	11-20P	11-30R	11-30P	11-50R	11-50P		

3 pole 4 Wire Grounding										
125/250V	14-15R	14-15P	14-20R	14-20P	14-30R	14-30P	14-50R	14-50P	14-60R	14-60P
3Ø 250V	15-15R	15-15P	15-20R	15-20P	15-30R	15-30P	15-50R	15-50P	15-60R	15-60P
3Ø 480V	Reserved For Future Configurations									
3Ø 600V	Reserved For Future Configurations									
4 Pole 4 Wire										
3Ø Y 120/208V	18-15R	18-15P	18-20R	18-20P	18-30R	18-30P	18-50R	18-50P	18-60R	18-60P

NEMA Configurations for general-purpose locking Plugs and Receptacles

Voltage	15 Amp	20 Amp	30 Amp
2 Pole 3 Wire Grounding			
125V	L5-15R 120V	L5-20R	L5-30R L5-30P
250V	L6-15R 208-240	L6-20R L6-20P	L6-30R L6-30P

3 pole 4 Wire Grounding			
125/250V		L14-20R L14-20P	L14-30R L14-30P
3Ø 250V		L15-20R L15-20P	L15-30R L15-30P
3Ø 480V		L16-20R L16-20P	L16-30R L16-30P
3Ø 600V			L17-30R L17-30

4 Pole 5 Wire Grounding			
3Ø Y 120/208V		L21-20R L21-20P	L21-30R L21-30P
3Ø Y 277/480V		L22-20R L22-20P	L22-30R L22-30P
3Ø Y 347/600V		L23-20R L23-20P	L23-30R L23-30P